"Stepping-Stone" Recording Studio: An Intermediate Guide to the Project Studio

An Honors Thesis (MMP 495)

by

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Abstract

Audio production is a growing trade. It includes music production, foley, live sound reinforcement, radio production, dialogue replacement for film and TV, and more. Many seek to pursue a career in this field, but do not know how or where to begin—or whether to seek a commercial position or to attempt a career as a freelance engineer. This essay will explore one of the many ways to make a career as an audio engineer: home recording in a project studio. It is a synthesis of primary and secondary research on the subject of home recording and acoustic treatment that is meant as a guide for graduating audio students, amateur audio engineers, or even recording/audio/music enthusiasts. There is an increasing fear—especially in the graduating audio student population—of the expense that starting a home-based project recording studio requires. Thus, the essay focuses on how the reader can make the most of what he or she has and what he or she can afford. It includes information about the author's experience building acoustic panels, administering acoustic tests, comparing and contrasting recording equipment, and more in order to show that it is possible to create a studio on a budget. The idea of the "Stepping Stone" recording studio stems from the fact that the concepts and equipment, can be built upon later—as one's career grows.

Acknowledgements

First, I would like to thank Dr. Robert Willey for his work as my thesis advisor. Without his continuous efforts and suggestions, this project would not have been able to come to fruition.

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Patrick Weaver offered his help during the recording portions as well. He spent several hours with me setting up microphones, audio interfaces, and recording sessions. His assistance was indispensible and allowed me to work faster.

Jeff Seitz allowed me to use MMP departmental equipment such as a video camera, speaker stands, microphones, and more that added a lot of depth to my project. His generosity and trust in me is very much appreciated.

I offer a big thank you to all of the professors in the MMP department that have helped me succeed as a student—and someday, as a professional. Your time, patience, understanding, and knowledge have meant more than I can ever say.

Finally, I would like to thank my family and friends for their continued support not only throughout the process of this project, but also throughout my four years at Ball State University. A special thank you goes out to my parents, Donna and Brian Swingley, for helping me in every way that they could; most notably, for this project. My mom took the time out to help me find the materials that I needed for building the acoustic panels, and my dad added his woodworking knowledge to help me build the panels...and make sure I didn't cut my hand off.

Without all of you, I certainly would not have been so successful.

Contents

Introduction: "Like Drinking Water Out of a Fire Hose"

I have always been fond of colloquial phrases—ways of saying things without directly saying them. Like saying "I haven't seen you since 'Nam!", instead of saying "I haven't seen you in a long time!" They keep things interesting and sometimes catch people off guard. When I was a kid, my grandpa always had the strangest and funniest ways of phrasing things. Colloquial phrases are a main part of his speech. I think he was trying to confuse me by doing this when I was a kid. Regardless, these phrases stuck with me.

One in particular comes to mind when I think of my knowledge of audio and music production before coming to Ball State University: "You could stick what I remember about Algebra in my eye and I wouldn't feel it." By this, he just meant that he does not remember anything about that strange, alphabetic math that you learn in high school.

Of course, it is not meant to be taken literally. I am sure he remembers *something* about Algebra. But, in my case, before my time at Ball State, you could have literally stuck what I knew about audio production in my eye and I would have been none the wiser

Therefore, during my four years here, *everything* I learned about audio production was new. I heard another phrase recently that sums up this huge influx of knowledge. Jeff McDonald, Senior Vice President of Human Resources at Sweetwater Sound, said it in reference to their training course for new Sales hires: "It is like drinking water out of a fire hose."

New information was coming at me with such an alarming rate of speed, that it was difficult to catch it all. But over the last few years, I have learned to manage that.

My Background in Audio Production

My freshman year, I took part in an immersive learning class with the radio show on IPR called The Scene and was then thrust into learning the audio production software Pro Tools. Anyone who knows Pro Tools can attest that learning this software is very difficult and takes a lot of time. Four years later, I still have a lot more to discover about it.

My sophomore year, I started to learn about the recording process and concepts. I was introduced to things like signal flow, microphone inner workings, polarity, phase, preamps, outboard gear, monitoring, gain staging, and more. This is also the year that I took a live sound internship at Be Here Now in The Village and became Assistant Production Director for Ball State's student-run radio station, WCRD. I had never done live sound or radio production before, so there was a lot to learn. For example, I gained knowledge of live sound miking techniques, feedback control, monitor mixing, live sound gain staging, the audio freeware called Audacity, how to write and produce a radio commercial, and more. Not to mention, I learned how to think quickly on my feet.

My junior year, I moved up to Production Director of WCRD, live sound engineer at Be Here Now, and started another semester with The Scene as a student producer. With these new positions, I built even further upon my existing knowledge. It was an exciting and scary time.

The summer after my junior year, I took a job working as a member of the Production Crew at Interlochen Center for the Arts. There, I learned even more about live sound reinforcement than I ever thought existed, such as backlining, hanging arrays, hanging lights, wireless microphones, and how to safely move heavy equipment.

My senior year rolled around and I found myself in the position of Treasurer for Ball State University's chapter of Audio Engineering Society. Before the year was over, I was Vice President! As an AES executive officer, I took part in planning and executing various events like the Central Indiana Audio Student Workshop, the Battle of the Bands, the Audio Professional Speaker Series, and more. I also worked out a mutually beneficial agreement with Ball State's Association of Collegiate A Cappella—we do live sound reinforcement for their shows and they help us advertise. I also taught a few recording and mixing workshops during this year. I, who did not know a single solitary thing about production before coming to Ball State, was *teaching* workshops about it before graduating.

My journey at Ball State University was an amazing, empowering, and insightful one. I hope that the readers of this essay can gain something from it.

Part 1: What is a "Stepping-Stone" Recording Studio?

Where the Name Comes From

According to Merriam-Webster, a stepping-stone has two definitions. One is a literal definition, and one is figurative. The literal definition describes a stepping-stone as: "a large, flat stone that you step on to cross a stream". Not quite relevant for a recording studio—I don't know of many folks that have streams in their home studios. The figurative definition explains that a stepping-stone is "something that helps you get or achieve something". Bingo. The stepping-stone, therefore, is not the end goal, but rather it is a means to an end. Thus, the "stepping stone" recording studio is not meant to be a final product, but a phase of the process of creating a home studio. It is meant to create a basis for beginning the career of freelancing.

Who Is It For?

It originally started as a guide for graduating audio students to help them get into freelancing and making money after college, but anyone that is interested in recording, mixing, or producing audio at home will be interested to read the findings contained in this essay. I have noticed a particular interest in the DIY acoustic paneling portion of this project. Many of my peers have found that to be the most intriguing, as they can do research on their own about the gear and principles surrounding it. So now the target reader would be anyone that is an amateur or intermediate audio engineer that wants to begin his or her own home studio. Those who are looking to expand can find some useful information as well. Another demographic that is targeted is musicians who are tired of paying someone else to record their music and need or want to start producing their music at home. The last target reader is the music enthusiast who wants to learn more about the production process and how it can be done at home. Whether they are just curious or want to try it themselves, this guide is a good start!

Why and How I Chose This Project

Watching that graduation date loom closer, I found myself apprehensive about the future. Where would I go? What would I do? How would I make money freelancing? What gear do I need? How do I know what is good and what isn't? What should I spend my money on? Dozens of questions swirled through my mind. So I decided to answer them before graduation, rather than after. Then the idea came to make a project out of it. If I was going to spend a lot of time researching concepts, different pieces of gear/microphones, and acoustic treatment, then why should I not find a way to organize my findings and quantify them? And get credit for it in the process! It is truly a win-win situation.

Why It Is Important

Very rarely does an amateur audio engineer (or graduating audio student) have enough money or expertise to design, build, and maintain a full, professional-grade studio. Many professional-grade home studios exist, but they require a lot of time, money, and skill to implement and use. This is why many use a basic set-up in the early stages of their careers. This basic set-up is what I like to call the "stepping stone" studio. It can be used effectively right *now* to make money or to do what you love, but it can also be built upon. All of the pieces of the "stepping stone" studio can still be used later when one decides to expand. Rather than focusing on buying "economy gear" (or gear that is cheap—made cheap and easily accessible—and not made to last), this essay will focus on good quality products at an affordable price. It explains why the investment of good quality gear at a slightly higher price is often (but not always) better than buying the cheapest option.

Part 2: It All Came Together in Stages

Stage One: Planning

This was the easiest of the stages. Coming up with ideas related to this project was virtually effortless. In fact, I came up with more ideas than could be implemented in one semester and had to whittle down some things for time's sake. I had many planning sessions with my thesis advisor, Dr. Willey, and spoke to several peers to find out what they thought would be best to include in the project. Some brought up concepts I hadn't thought of. Then, I wrote out several lists of topics that I wanted to cover and gear that I wanted to test.

Stage Two: Research/Finding the Materials

During this stage, I was able to find what seemed like a wealth of information. This was very exciting. But when it came down to it, a lot of the sources I found said the same or similar things. A lot of the sources about room and studio acoustics talk about panels, baffles, diffusers, absorbers, bass traps, foam, acoustic clouds, and more. But what about those of us that can't really afford all of the fancy stuff just yet? What do we do? Then I found them, the books for the beginner and the veteran alike: *Acoustic Design for the Home Studio* by Mitch Gallagher and *the Studio Builder's Handbook* by Bobby Owsinski. Both books turned out to be vital assets to this project. Not only do they explain acoustic principles in simple and easy to understand ways, both provide ways to help remedy them without it costing an arm and a leg, especially Gallagher's book.

Another resource that was fundamental to this project was the "DIY Bass Traps & Acoustic Panels" article and videos by ADSRsounds.com. This article included a PDF tutorial, detailing each step in the process. I thought that I would not need to use it very much, but the PDF proved to be a very valuable resource while building the panels. During this time, I also took several trips to Lowe's, JoAnn Fabrics, and Wal-Mart to get the materials that I needed to build the panels.

Stage Three: Building the Panels

During Spring Break (March 2016) I did not fly to Panama City or Miami to soak up the Sun. Instead, I drove home to Dayton, Ohio in order to build acoustic panels with my Dad—and it was fantastic. Even though they are not the main focus of my project, building the panels with my Dad was a better and more fruitful experience than spending all of my money in Florida. I learned a lot about how to read directions, how to be safe with a table saw, and why it is always important to create a pilot hole in wood *before* you put the screw in.

I got the idea to build my own DIY acoustic panels after seeing an article about it on ADSRSounds.com—a music production website dedicated to people of all trades within the music world. It includes several tutorials about various projects, tasks, programs, or production tricks. I happened to stumble upon a very detailed tutorial called "DIY Bass Traps & Acoustic Panels", posted by user wildtek. It includes several videos showing how to build the panels and a PDF from readyacoustics.com called "DIY Bass Traps Made Easy", written by Joel DuBay—the links to this PDF and to the article are included in the Bibliography. These panels are simply made by creating a wood frame, placing 4 inches of acoustic absorption material on top, and then finally by tightly wrapping cloth around and stapling it to the back of the frame to hold everything together.

You will notice that these panels are called "bass traps" and "acoustic panels" almost interchangeably. In the case of these panels, they have a few different uses. I used them as bass traps for the purposes of testing my bedroom's acoustics and they worked decently well. This bedroom is a terrible acoustic space and is very hard to control. They could also be hung on the walls as reflection absorbers (as there are many types of "acoustic panels"), but are simply more suited for bass trapping due to their thickness (Figure 1). Each finished panel was approximately 6 inches thick, with 4 inches of absorption material and 2 inches of wood frame.

Figure 1: Finished panel on work table.

It took approximately 9-10 hours and $100 of materials to build three panels. The most expensive material was the Rockwool that was used as the absorption material inside the panel. It costs about $55 to buy a pack of six 2-inch thick pieces of Rockwool. I purchased the pack of six and used two in each panel. If you were to buy similar premade acoustic panels through websites such as acoustimac.com, each would cost anywhere from $20 to $80 depending on the dimensions and materials.

Here is an overview of the process I took to build one:

Step 1: The Frame

To build the frame, I needed two 8-foot pieces of 1x2 wood cut at 22 and 48-inch intervals. Each frame needs two pieces of 22-inch, 1x2 wood and two pieces of 48-inch, 1x2 wood (Figure 2). The extra wood from the 8-foot pieces were used to build another panel.

Figure 2: Wood for the frames.

You will notice, if you look closely at Figure 2, that the pieces of wood I used were not 1x2. They were actually 2x3. This was an oversight on my part. To correct this, I simply cut off 1 inch from each piece, and made the frame the proper dimension (24x48).

To make the first corner, the 22-in piece of wood was placed at an angle with the 48-in piece. The shorter one was placed on the inside of the angle (Figure 3).

The two pieces were then connected with a 2.5- in wood screw. The same was done for each of the four corners.

Then, a metal bracket was screwed into each of the four corners, using half-inch wood screws (Figure 4).

Figure 3: First angle. Left piece of wood is the 22-in piece. Right piece of wood is the 48-in piece.

Figure 4: Metal bracket in corner of frame

Step 2: Sanding

After the frame was built (Figure 5), it was time to sand off all of the rough edges so they would not snag on the cloth. To do this, I used a simple belt sander (Figure 6).

Figure 5: Completed backing frame

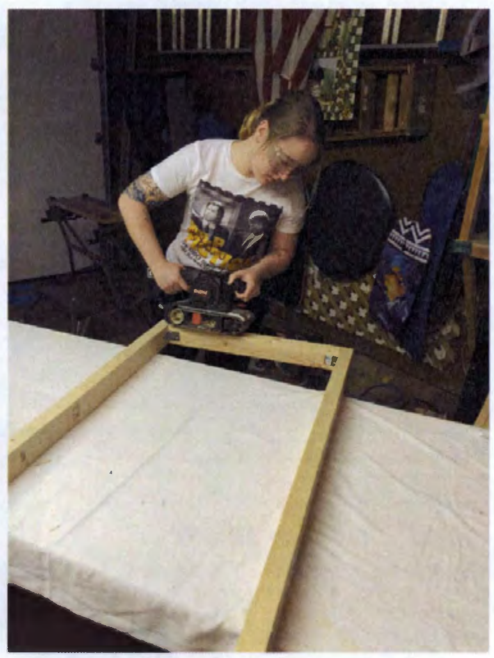

Figure 6: Smoothing the rough edges with belt sander

Step 3: The Cloth, Pt. 1: Ticking Fabric

To start the final steps, I needed to attach 24x48-in of ticking fabric to the front of the wooden frame (Figure 7). This fabric is used to hold in the absorption material. For this, I used basic muslin fabric, as it is relatively inexpensive and durable. Attaching this fabric is relatively easy, though it did take two people to do it—one to stretch the fabric across the panel and another to staple.

Figure 7: Muslin attached to the backing frame

Step 4: The Cloth, Pt. 2: "Nice" Fabric

The "nice" fabric must be aesthetically pleasing, thick, and durable, but must also have a bit of stretch to it. There are several options for this requirement and the people that work at fabric stores make this decision much easier. I laid nicer fabric down as flat as it could possibly be on the table before placing the absorption material on top of it.

Step 5: The Rockwool

The material that I used for absorption is called Rockwool. I purchased it in 2-inch thick slabs with dimensions of 24x48-inches from a website called Acoustimac.com. There are other materials that can be used as well, such as fiberglass or any other mineral fiber insulation material.

After placing the Rockwool on top of the nice fabric (Figure 8), I then put the fabric on top of the Rockwool (with the muslin facing inward—Figure 9). The nice fabric was then stretched around the Rockwool and the frame all the way around to the back. I then stapled it to the back of the frame, doing so on each side, until the whole panel was covered (Figure 10).

Figure 8: Rockwool on top of fabric

Figure 9: Frame on top of Rockwool

Figure 10: Stapling the fabric

Figure 11: Completed acoustic panel

Stage Four: Testing

The testing stage includes a lot of subjectivity. The goal here was mainly to find the things I liked and would use, and explain why I liked them. This stage took place over several weeks and months.

Though subjectivity plays an important role, the hard facts are equally significant: such as, pricing, technical specs (and how well the products live up to them), and overall limitations.

I have been doing **microphone** testing for the past three years, so the work that I had to do in that realm for this project was minimal. What I really needed to know was what audio interfaces, acoustic treatment, and speakers were the best value.

As stated before, microphone testing is something that I have been inadvertently doing over the past three years while working on various recording projects. I have used many of the different dynamic, condenser, tube, and ribbon microphones that are available in the Ball State Music Technology studios. If there is ever a microphone I am curious about using or hearing, chances are, the studios have it. All of the microphones I used for this project (except for the microphone I used at home) are owned by the Ball State studios.

The **audio interface** testing took place on February 27th, 2016. I brought five different audio interfaces into one of the recording rooms located in the Ball State

Music Technology Studios and recorded the same 40 seconds of audio using the same microphones in the same placement for each interface. The reason for doing this was to test the quality of the preamps in each device. By using the same microphones and placement and recording the same audio each time, I was able to eliminate excess variables and make better judgment of the sound quality.

All of the microphones that were used for the studio recordings are condenser microphones: for vocals, the sE Electronics sE2200a II and for acoustic guitar, the sE Electronics sE4's in a stereo pair. These are the five audio interfaces that were used: the Apogee Quartet (Figure 12), Presonus AudioBox iTwo (Figure 13), Focusrite Clarett 2Pre (Figure 14), Resident Audio t4 (Figure 15), and Focusrite Scarlett 6i6 (Figure 16).

Figure 12: Apogee Quartet (Photo from Sweetwater.com)

Figure 13: Presonus AudioBox iTwo (Photo from Sweetwater.com)

Figure 14: Focusrite Clarett 2Pre (Photo from Sweetwater.com)

Figure 15: Resident Audio T4 (Photo from Sweetwater.com)

Figure 16: Focusrite Scarlett 6i6 (Photo from Sweetwater.com)

A CD with the recordings from all of the tests is provided. The first five tracks are the recordings from each of the interfaces. The next seven tracks are the recordings from the acoustic treatment tests.

The **acoustic treatment** and **speaker** testing took place over the weekend of March 19th, 2016. The "studio" was set up in the bedroom of my home—a bedroom with too many acoustic problems to even count, including flutter echo, room modes, thin walls, lack of insulation, and more. For these tests, I used the gear that I already own: a Presonus AudioBox iTwo interface, a Blue Spark microphone, a pair of JBL LSR305 active monitors (speakers), an On-Stage Euro Boom Microphone Stand, a pair of Sennheiser HD280 closed studio headphones, and Avid's Pro Tools DAW. The acoustic treatment that I used included: the three panels that I built over Spring Break, a bed, pillows, drapes, blankets, and clothes. The closet functioned as a large bass trap, as I kept the door open and filled it with clothes and blankets (absorbing materials). The three panels that I built, along with the bed, were placed in each of the four corners of the room. The pillows were placed around the wooden dresser. The drapes were hung from the window and bunched up to create optimal absorption. A thick comforter was hung over the mini fridge to minimize its hum and the reflections that came off of it. The blankets were also hung from large picture frames, placed directly behind the monitors, to minimize reflections coming from the wall behind the monitors.

The tests included "Before" and "After" iterations, where the "Before" refers to the testing and recording done before the acoustic treatment was put in place and the "After" refers to the testing and recording done after the treatment was put in place. Each iteration included a clap test; vocal, acoustic guitar, and voiceover recordings; RTA tests using pink noise, sine tones, and sweeps; "Sweet Spot" tests; and room mode, bass buildup, and standing wave checks using pink noise and sine tones.

After analyzing the room for potential problems, I found these, which are very common and found in most living spaces: mini fridge in the room produces slight hum when it kicks back on; the bathroom and laundry room are adjacent to the bedroom; the walls are thin and have very little insulation, so when people inside or outside the house talk, or when cars pass by, there is very audible noise; the house creaks with the slightest movement; the house has a basement and thin floors; the house's resonant frequency is 32 Hz, which was constantly present in all RTA tests even though the JBL speakers cannot produce that frequency—and greatly increased as a car passed by outside (Figure 17); and there is a very audible room ring and flutter echo that is subtle when talking but very prominent with clapping or other loud sounds with normally quick decay time. The ring persisted, even after the acoustic treatment was hung. I believe the thin walls and scarce insulation within them are the cause.

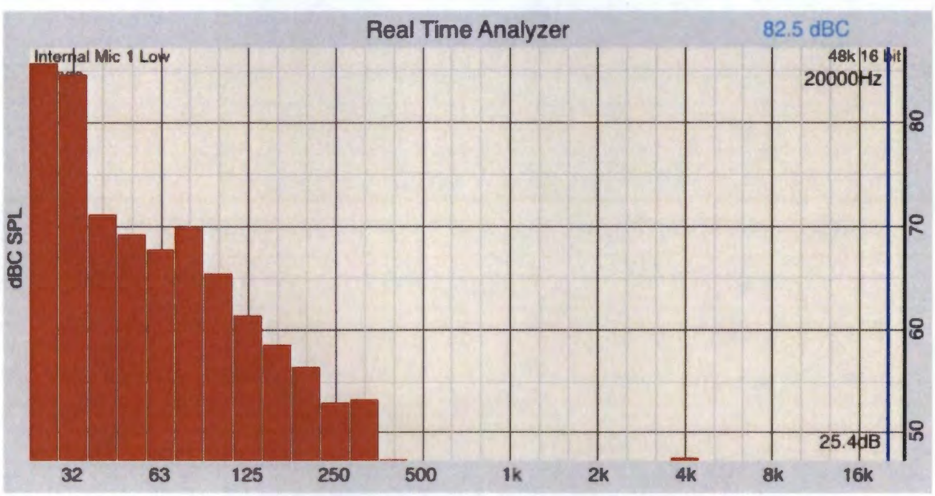

Figure 17: Screenshot of the RTA showing the increase in pickup of 32 Hz as a car drove by the house.

Before

In the preliminary tests, I left everything in the bedroom as is. All of the furniture stayed in its usual place and there was no deliberate treatment placed in the room (Figure 18, 19, & 20). The bedroom is 10ft by 14ft, with 8.5-foot ceilings.

Figure 18: Vocalist (Samantha Doub) is seen standing in front of the open closet. Photograph taken from the doorway into the bedroom.

Figure 19: Doorway into bedroom.

Figure 20: Desk and entertainment stand, taken from bed.

I began by administering a clap test. I stood in the center of the room and clapped. The purpose of this was to hear the "live-ness" of the room. Upon hearing the room ring and flutter echo, I decided it was necessary to try to find the culprit behind those terrible sounds. I walked around the room, clapping in various places and listening for a rise in amplitude and intensity of these rings and echoes. I found that the echo was worse on the end of the room with the entertainment stand and desk and at first, believed those two pieces of furniture to be the culprits. I was incorrect.

After moving the furniture and placing acoustic treatment, the problem persisted. I learned that the cause of the echo and room ring is the parallel walls coupled with their thinness. The reason it was so much worse on the end with the desk and the entertainment stand was not due to those pieces of furniture. Two of the walls on the other end of the room are outside walls and therefore have brick and insulation on the other side of them. These two materials are good sound absorbers. The other wall has a large closet that is filled with clothes, which also absorbs some of the sound. The wall where the echo and ring were most audible is one that leads directly into another bedroom. This wall is thinner than the others, as there is not much insulation between the drywall.

After clapping numerous times and annoying my roommates, I began testing the response of the monitors using an RTA (Real Time Analysis) iPhone app called AudioTools (it is $10 in the App Store and I highly recommend it). The RTA analyzes the frequency content of sound. It is extremely useful in situations where one needs to tune a room (often used in studios or mixing environments) or tune a set of speakers (often used in live sound environments). I played pink noise—a signal that includes all audible frequencies, each distributed in at a level that allows them to be perceived at equal loudness—, sine tones, and frequency sweeps.

I found that the JBL monitors could audibly produce 44Hz-19kHz, which is amazing for a pair of near-field, two-way speakers with only 5" drivers. I could hear 20kHz, but had to turn the monitors up quite high for it, so I do not think it is appropriate to say that it is produced "audibly". The technical specifications for them state that they have a frequency range of 43Hz-24kHz. I could not get 43Hz to be audible enough for me to count that, and the Signal Generator I have only goes up to 20kHz, so I would say that these monitors fit their specs pretty well.

After testing the frequency response of the speakers themselves, I then went on to test the "Sweet Spot" of the listening position at the desk (Figure 21). This is the area of optimal listening in between a pair of monitors. This spot is the best for hearing frequency content, stereo width, imaging, and balance. To test this, I played pink noise through the JBL's and moved my head left, right, up, and down, focusing mainly on changes in amplitude throughout the frequency content and marking the ear position on a tape measure. Before any treatment—and before moving the speakers to a better listening position in the room—I found that the "Sweet Spot" was 1.5 ft. wide, 8 in. tall, and about 1 ft. front-to-back.

Figure 21: Desk space

Then came the actual recording. I first recorded a vocalist singing into the Blue Spark microphone. I placed her in front of the open closet door, attempting to keep some of the room ring out of the recordings. I quickly found out that Blue's pop filters are not great. I ended up using pantyhose as an additional pop filter on this microphone for all of the subsequent recordings.

Next, I recorded acoustic guitar, while seated at the desk. The microphone was pointed at the sound hole of the guitar and placed approximately 6 inches away from it (Figure 22).

Figure 22: Recording acoustic guitar.

Finally, I recorded a simple voice-over. These are, arguably, the three main types of recordings that are done in home studios, so I found them to be the most significant. During the recording process, I simply listened back to the recordings using Sennheiser HD280 headphones. I did not have the interface connected to the monitors at this point in the testing phase.

<u>In Between</u>

In order to do the *"After"* tests, I first had to move the unnecessary furniture out of the bedroom—the entertainment stand and the metal desk. Then, I moved the speakers and placed the three bass traps in each corner, using the mattress as a fourth. For the rest of the DIY acoustic treatment, I used pillows, drapes, blankets, and clothes. I placed the pillows around the dresser, hung the drapes above the window—keeping them bunched up—, placed a comforter over the mini fridge, and hung up large picture frames with blankets draped over them. These frames were placed on the wall directly behind the speakers.

In Figure 23, you can see the speaker placement, two of the panels, the picture frames with blankets, the drapes, and the comforter on the mini fridge.

Figure 23

Acoustic Treatment and Speaker Placement

The speakers were placed on stands, rather than keeping them on the shelf of the desk for two reasons: 1) the desk is metal and was causing reflections, and 2) the desk was too close to the wall (therefore the speakers were too close to the wall) and there were reflections coming from that as well. The speakers needed to be farther away from the wall and to have some sort of absorption behind them. These particular speakers are rear-ported, which means that the lower (bass) frequencies come out of the back of the speaker. While bass frequencies are omni-directional, this still poses a significant problem if you have the speakers too close to a wall. These bass frequencies "couple" with large surfaces such as walls and cause problems such as bass build-up in your room. This can be a detriment to the mixing and mastering processes.

In order to be able to get the speakers closer to the wall (within 2 feet), I used a -2dB frequency trim. This trim attenuates low frequencies by 2 decibels. It is meant to help in situations like mine—situations where the speakers need to be closer to the walls than suggested. There are various schools of thought in regard to speaker placement. Here are a few of them:

1. Golden Mean – Says the speakers should be placed 38% of the way into the room from the wall they are facing away from. In the case of the bedroom, since the length of the room is 14ft, this would mean the speakers should be

1. 5.32 feet into the room, which is impractical and simply not possible for a bedroom studio.
2. 70% Rule – Says the speakers should be placed 70% of the width of the room away from the wall they are facing away from. In the room, that would mean they should be 7ft away from the wall (10ft x 70% = 7ft). Again, this is very impractical for a bedroom studio.

I then sat down and had a friend aim the cones of the speakers directly at my ears in order to create a good listening position (also called "Sweet Spot). This was the final step to be taken before beginning the "*After*" tests.

A note about <u>first reflections</u>: The first reflections are considered some of the most important that need to be acoustically treated. Unfortunately, I could not place the acoustic panels where the first reflections were to hit. This is due to the fact that they occur right where the window in the bedroom is located on one side of the room and right where the closet and light switches are on the other side of the room. In this situation, I had to make due. I used the curtain on the window to catch the reflections from that side and a comforter/clothes in the closet to catch the reflections from the other side.

<u>After</u>

Once everything was in place, I started by performing the same clap test that I had used in the "*Before*" tests. This was when I found that the furniture was not the problem that was causing the room ring and flutter echo. Rather, it was the thinness of the walls and their lack of absorption. These two problems were abated by all of the acoustic treatment that I placed throughout the room, but only slightly. This was slightly discouraging, but hardly surprising. Bedrooms are not the best acoustic spaces—especially bedrooms in college houses that are made about as cheaply as possible (but you did not hear that from me). Regardless, I made the best of what I had, which is the entire purpose of the project.

Then, I did the same speaker tests as before. I again used pink noise, sine tones, and a frequency sweep, listening for room modes, standing waves, and bass build-up. I found that there was a rather large bass build-up in the center of the room from 60Hz-90Hz (Figure 23 & 24).

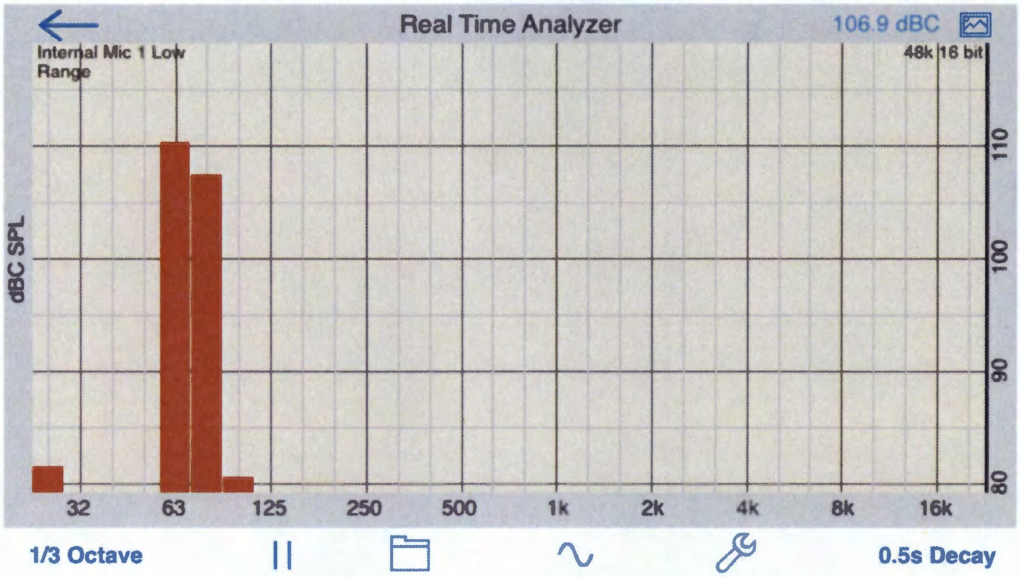

Figure 23: RTA showing the large boost of 60Hz-90Hz

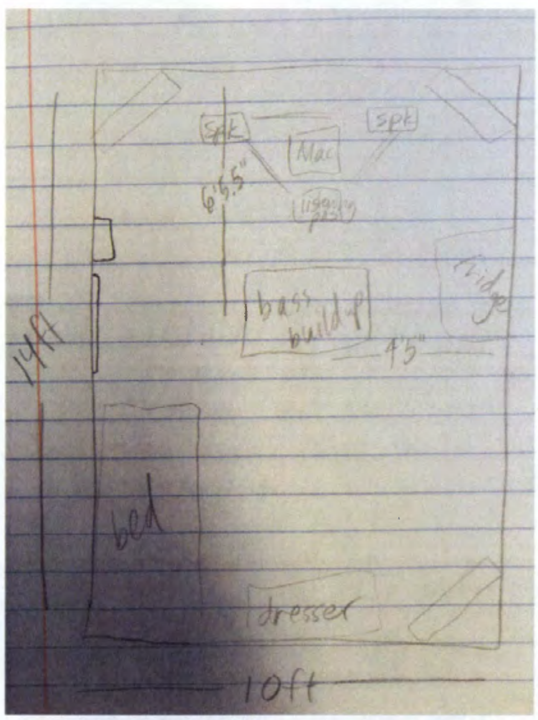

Figure 24: Drawing of bedroom showing location of bass build-up

While testing the new "Sweet Spot" dimensions, I found that it had increased in size with the new speaker placement. The speakers were placed further apart, which widened the stereo image that the speakers projected. The new "Sweet Spot" measured 2ft3in wide, 1ft tall, and 1ft6in front-to-back. This is a pretty significant improvement.

When the speaker testing was complete, I moved on to the final recordings. The vocal recording proved to be more difficult than expected. I purchased a

MudGuard by Auralex (Figure 25) to use while recording vocals. Ironically, this piece of acoustic foam made the recording sound muddy (there was a boost in the low-mid frequency content) but it successfully isolated the vocals and reduced the tinny quality that was present in the "*Before*" recordings (refer to Recording 6).

Stage Five: Analyzing and Editing the Recordings

The improvement in sonic quality between the "*Before*" and "*After*" recordings is relative. Whether you prefer the first or the second will depend on the style of song and the way you perceive music. As previously stated, there is a significant change in the frequency content and timbre of the voice between the two recordings. Recording 6 (before) has more high-mid frequency content and is therefore brighter and even harsh sounding. Recording 7 (after) has some extra low-mid frequency content that can be perceived as "muddy". However, in the "*After*" recording, the high frequencies are also smoother and less harsh.

The MudGuard is meant to isolate the vocals and prevent other noises or unwanted room ambiance from being picked up by the microphone. It does this, but also unfortunately introduces a bit of a boost in the frequency band 200Hz-300Hz. This can easily be carved out with an equalizer (whether analog or digital). In Recording 8, you can hear the sound of the voice open up, as I have used the generic 7-band parametric equalizer (EQ) plug-in that comes with the Pro Tools DAW to attenuate the 200Hz-300Hz frequency band by 2.4dB (Figure 26).

Figure 25: MudGuard wrapping around the microphone

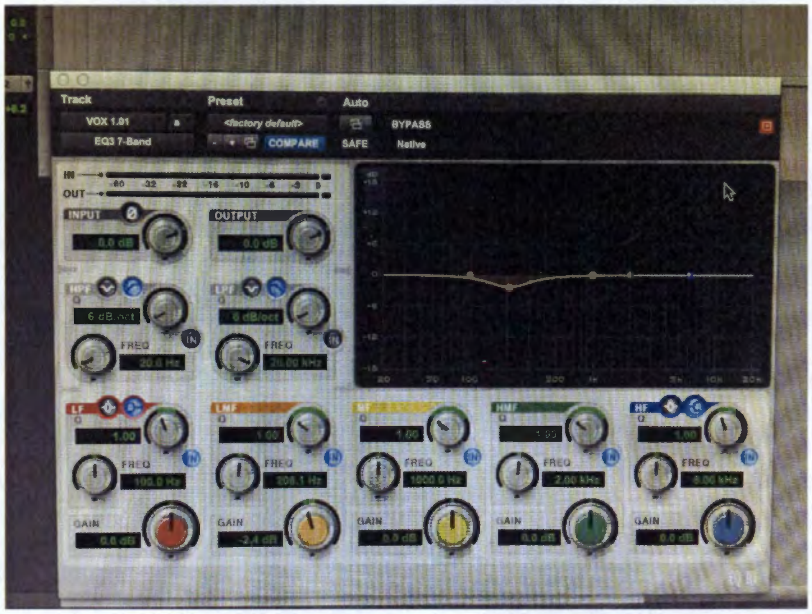

Figure 26: Photo of EQ plugin used to edit vocal track. Shows where the low-mid frequency content around 200Hz-300Hz was attenuated by 2.4dB

The differences between the voice-over and acoustic guitar recordings "Before" and "After" were also subtle. The editing that needed to be done for these four recordings (Recordings 9-12) was minimal; I really only needed to gain stage and make sure volume levels were consistent. The subtle differences between these recordings made it really difficult to judge which I preferred and which I felt sounded "better". When it really comes down to it, what I prefer may be different than what someone else prefers. What is really important is controlling acoustics during playback for editing and mixing. If your acoustics are not under control in this setting, you will not hear the audio correct and will make bad decisions about the mix/edits.

While editing the initial five recordings (done with Joy Mills and Patrick Weaver in February), I used the audio that was tracked using the Apogee Quartet interface as a reference—as this interface had the clearest pickups with the best quality recorded audio at the highest level. In order to do objective listening, I needed to make all of the five recordings the same volume and edit them all in similar ways, so as to not make one stand out falsely. During the editing process, I only focused on panning the guitar tracks left and right, getting the proper gain staging/leveling, and adding compression to vocals to control their transients—using the same plugin each time (BF-76). For each track, I increased the Master fader to be K-20. This was to get the audio to a loud enough level to really be able to listen to.

The recordings done with the Apogee interface needed very little editing. I introduced some light compression on the vocals and panned the guitar tracks left and right. The AudioBox recording, on the other hand, needed a lot of gain to be added to the right guitar channel (11.2 dB) and to the vocals (5.2dB) to get the signals up to a comparable level. The Clarett2Pre recordings also needed significant gain to be added to the right guitar track (16.1dB) and to vocal track (12.1dB). Some noise was also introduced into vocal track during the recording process—which I left it in. The recordings done with Resident Audio interface needed the least amount of added gain (besides those done with the Apogee, of course). The gain on the vocal track was increased by 7.8dB and right guitar channel by 8.6dB. The Scarlett6i6 recordings required a gain increase of 16.1dB on the right guitar track and 7.8 on the vocal track. The right guitar track needed such attention on all of these recordings because the right microphone was placed where the neck and the body of the guitar meet and the left microphone was placed at the sound hole, which inherently provides more sound. The final edits for each interface are included on the accompanying CD:

Recording1 – Apogee Quartet
Recording2 – AudioBox iTwo
Recording3 – Clarett2Pre
Recording4 – ResidentAudio T4
Recording5 – Scarlett 6i6

<u>Part 3: Conclusions – What Would Make for the Best "Stepping Stone" Recording Studio?</u>

Microphones

There are three different types of microphones that I focused this project on—mainly because these microphones are reviewed as being the best at their price point. They were: the sE4 (pair), the sE2200a II C, and the Blue Spark. These are not the only microphones that I have ever used or tested, but are the only ones that were used in the recordings for this project.

The sE4 is a small diaphragm pencil condenser that comes with a standard cardioid capsule. This capsule has the ability to be interchangeable. You can purchase omnidirectional and hypercardioid capsules and use them with the microphone, which makes it a very versatile option. This pair of microphones proved to be quite useful. They produce a nice sound and are versatile. Unfortunately, they are no longer produced or sold new. You can, however, buy them pre-owned for a price that ranges between $600 to $700 per pair. sE has a new version of this microphone. It is called the sE5 and is very comparable to the sE4 on paper. I have not had the chance to try this microphone out for myself. They are available for $400 a pair.

The other two microphones—the sE2200a II C and the Blue Spark—are both large diaphragm condensers with cardioid pickup patterns. Both come with shock mounts and pop filters as well. However, the shock mount and pop filter that come with the Blue microphone are less than desirable. Overall, I was less than pleased with the Blue Spark. It is not a terrible microphone, but the audio quality that the sE2200 offered was miles ahead of the Spark. I would choose sE's microphone over Blue's any day—and at a price of $300, it is a really great deal.

Audio Interfaces

The five interfaces that I tested in February are: the Apogee Quartet, Focusrite Clarett2Pre, Focusrite Scarlett6i6, Resident Audio T4,Presonus AudioBox iTwo. Of these, I found the Resident Audio T4 to be the best option for the price. It is only $250 and has 4 combo inputs (¼ or XLR capability), 4 balanced TRS outputs, MIDI in/out, and 24-bit/96kHz audio quality. Not to mention, it had some of the most clear, high-level preamps of the five options (besides the Apogee, which is—at nearly $1400—in a very different price category). The only negative about this interface is that it is only compatible with Thunderbolt connections. However, it comes with a Thunderbolt cable and all of the software drivers needed. Overall, it was one of the easiest to set up and record with.

Acoustic Treatment

The DIY acoustic panels that I built are 6 inches thick. They have 4 inches of Rockwool at the front and 2 inches of wooden frame at the back. This makes them difficult to use for anything other than bass-trapping, as they would stick out from the walls quite a bit if they were hung at, for example, the first reflection points. This is impractical for a home studio, unfortunately. I built them to be used for either purpose, but right now, I can really only use them for one. Though this is an unfortunate situation I find myself in right now, I am still very glad that I took the time and spent the money to build the panels and plan to build more of them. But next time, I will plan to build them with 2 inches of Rockwool instead of 4 (and buy the correct dimension of wood) and see if that extends their functionality.

The at-home acoustic treatment that was used included things that I already had on hand, such as blankets, comforters, drapes, pillows, and a mattress. These remedies were somewhat useful, but overall did little to improve the sound of the room. I budgeted too little money to acoustics for this project. Learn from my mistakes. Spend more than $100 on acoustic treatment. Your ears and your projects will thank you.

Monitors/Speakers

The main set of speakers I used is a pair of JBL LSR 305s. I also used a pair of Event 20/20 monitors (speakers) during the editing process. Throughout my time at Ball State, I have been able to work using various sets of monitors, including the infamous Yamaha NS10s and the powerful Genelec 1037Cs. The JBL monitors that I use currently in my home studio set-up will not be the sole pair of monitors I use for the rest of my life. But, they are a great pair to start with, and will make great reference monitors later when I expand and purchase more.

The JBL LSR 305s are active, two-way monitors, which simply means that they have their own internal power supply (fed from an outlet) and that they have two output cones (a tweeter and a woofer). The crossover point between the two cones is 1725Hz. They are rear-ported. According to Sweetwater.com:

> [A] port refers to an opening in a bass reflex-type loudspeaker enclosure. Ports are usually tuned very carefully to create certain kinds of resonances and coupling with the air outside the cabinet. . .The purpose is to improve the bass response characteristics of the enclosure, which is often accomplished specifically by creating a controlled resonance of the air at a frequency just below the normal cutoff frequency of the speaker in the given enclosure.

The speakers also have balanced XLR and ¼" inputs, and low frequency and high frequency trims (LF trim used in some of the testing and editing processes). While testing the JBLs, I found that they have an audible frequency response range of 44Hz-19kHz—this is without any change in gain, which is pretty amazing for a pair of starter monitors with no subwoofer in the signal chain.

One of the most special features of the JBL LSR 305 monitors, is the large HF tweeter flare, which JBL calls the "Image Control Waveguide". This design originally developed for JBL's M2 Master Reference Monitors, which are at a much higher price point than the LSR 305/308 series. A review by *Sound on Sound* explains this waveguide quite well:

> The secret to the waveguide is in the fine detail of the shape of the flare, in particular those 'Klingon forehead' ridges in the middle of the four sides. In addition to managing dispersion, the waveguide is also designed to time-align the tweeter with the woofer. In theory, by precisely controlling the horizontal and vertical dispersion of the Hi-Freq unit, and by minimizing phase issues at and around the crossover point this waveguide approach should lead to a better sense of mid-range focus, as well as a wider sweet spot.

They are offered with either a 5-inch woofer or an 8-inch woofer. The price is $300 for a pair of the 5-inch speakers (305s) and $500 for a pair of the 8-inch speakers (308s). I currently use the pair with the 5-inch woofer simply because my home studio is very small and located in a bedroom with low-frequency buildup. I would not want to add to that problem by buying a pair of monitors with too much low-end response. The bigger the low frequency cone (woofer), the more low-end response the monitor has.

Budget

The budget that I wanted to stay within during this process was $1,500. I felt this would be relatively affordable not only for me, but also for the readers. The total of each item category ended up being:

$700 – sE microphones
$250 – Resident Audio T4 interface
$100 – DIY acoustic treatment
$300 – JBL speakers

This brings the total to $1350, giving about $150 of wiggle-room, which can be used for more acoustic treatment or maybe another microphone.

Appendices:

A. Additional Resources

If you are interested in learning more about the topics discussed in this essay, here are some resources you can access online for free:

www.hairballaudio.com/blog/resources/category/diy-resources

www.musictech.net/2013/06/diy-studio-acoustics-tutorial/

www.soundonsound.com/articles

www.sweetwater.com/insync

Here are some books that are not free:

Anatomy of a Home Studio: How Everything Really Works, from Microphones to MIDI by Scott R. Wilkinson

Sound Systems: Design and Optimization: Modern Techniques and Tools for Sound System Design and Alignment [3rd Edition] by Bob McCarthy

The Science of Sound by Thomas D. Rossing

Mastering Audio: The Art and the Science by Bob Katz

B. Audio Examples

The audio examples listed below can be found on the accompanying CD.

Recording1 – Apogee Quartet
Recording2 – AudioBox iTwo
Recording3 – Clarett2Pre
Recording4 – ResidentAudio T4
Recording5 – Scarlett 6i6
Recording6 – VocalsBefore
Recording7 – VocalsAfterNOEQ
Recording8 – VocalsAfterWITHEQ
Recording9 – GtrBefore
Recording10 – GtrAfter
Recording11 – VObefore
Recording12 – VOafter

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